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Dewar, R. A.; Arnold, G. P.; Wang, W.; Drew, T. S.; Abboud, R. J.

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R.A. Dewar[a, b], G.P. Arnold[a], W. Wang[a], T.S. Drew[a], and R.J. Abboud[a, c]

[a]Institute of Motion Analysis and Research (IMAR), Department of Orthopaedic and Trauma Surgery, Tayside Orthopaedic Rehabilitation Technology (TORT) Centre, Ninewells Hospital and Medical School – University of Dundee, Dundee DD1 9SY, United Kingdom

[b]2/2 3 Abercromby Street, Glasgow G40 2HW, United Kingdom

[c]Faculty of Engineering, University of Balamand, Koura, Lebanon

Corresponding author: Professor R J Abboud
Email: r.j.abboud@dundee.ac.uk
Phone: +44 (0) 1382 383502

The effects of wearing an Ankle Stabilizing Orthosis (ASO) Ankle Brace on ankle joints kinetics and kinematics during a basketball rebounding task

Highlights

- First study to examine the bilateral effects of wearing an ankle brace unilaterally in a simulated athletic task
- Wearing an ASO ankle brace reduced ankle and foot inversion in the braced foot
- No differences were observed in the unbraced ankle between conditions

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Abstract (278 words)

Following an ankle injury, athletes sometimes brace the injured ankle in hopes of minimizing the likelihood of suffering a recurring injury. This study aims to evaluate the effects of wearing an Ankle Stabilizing Orthosis (ASO) ankle brace unilaterally on the dominant side on bilateral ankle joint kinetics and kinematics and peroneus longus EMG activity. Since a significant proportion of ankle injuries in basketball occur during rebounding, data was collected during a simulated rebounding task. Rebounding is defined as the act of retrieving a missed shot attempt. Subjects oftentimes jump vertically to acquire the basketball as it rebounds from the backboard or rim.

Sixteen subjects participated in the study (11 males, 5 females; mean age = 26.94 years, SD = 5.32; mean height 1.72 m, SD = 0.08; mean weight 73.95 kg, SD = 13.68).

Participants completed the rebounding task in braced (ASO) and unbraced (UB) conditions. Ankle and foot inversion angles, ankle inversion moments and peroneus longus EMG activity were recorded and analysed to determine the effects of wearing an ankle brace unilaterally.

In the dominant limb, when compared to UB, ASO reduced ankle and foot inversion, and increased ankle inversion moments. No significant differences were observed in peroneus longus EMG activity. In the non-dominant limb, no significant differences were observed for any of the parameters.

These results suggest that wearing an ASO ankle brace on the dominant ankle reduces maximum ankle and foot inversion angles without posing an increased risk to the unbraced leg. However, the increased ankle inversion moments in the braced ankle suggest that there are adjustments regarding force distribution, perhaps due to the restricted range of motion.

Key Words

Ankle, Brace, Inversion, Basketball, Rebounding, Landing

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Introduction

Ankle injuries are most common in sports that combine running and jumping, such as basketball [1,2,3]. Of these, lateral ankle injuries are the most common [4]. Basketball-related ankle injuries often occur while landing after rebounding, or the action of retrieving a missed shot attempt [2,5]. A number of factors are associated with the likelihood of suffering an ankle injury, but incidence rates are highest following a primary injury [5,6,7,8,9].

Due to the frequent occurrences of ankle injuries in basketball, many players wear ankle braces as both preventative and rehabilitative measures. Many studies have evaluated the effectiveness of ankle braces in reducing injury occurrence and their effect on lower limb kinematics and kinetics. A general consensus can be seen in the literature that ankle braces do indeed provide some degree of protection against ankle inversion in dynamic situations [10,11,12]. However, less is known about the effects of wearing ankle braces unilaterally on bilateral lower limb kinematics and kinetics.

There is some evidence that the dominant limb is at a greater risk of injury since it is often preferred for jumping, kicking and landing [13,14]. Furthermore, increased angular displacement and velocities have been observed in trials involving landing from a height, which also support this idea [15]. While many studies have focused on the effects of wearing ankle braces bilaterally, or only investigated the unilateral effects of bracing, no studies up to this point have examined the effects of wearing an ankle brace unilaterally on bilateral lower limb biomechanics.

Through the collection of kinetic and kinematic data, the present study aims to investigate the effects of wearing an ankle brace unilaterally during a basketball rebounding task. Ankle and foot inversion angles as well as electromyography (EMG) activity of the peroneus longus were recorded and analyzed. Additionally, ground reaction forces were measured to analyze the effects of the ankle brace on the ankle inversion moments produced while landing.

Materials and Methods

All data were collected at the XXX of the XXX centre, XXX Hospital and Medical School. Ethical permission was granted by the University's School of Medicine Research Ethics Committee prior to data collection.

Participants

Sixteen participants (eleven male, five female) agreed to take part in this study and were recruited by a number of means. Members of the University Women's Basketball Club and University Mixed Lacrosse Club were invited to participate via email. Recreational basketball players at the Institute of Sport and Exercise (ISE) were also invited to volunteer. In addition, a number of students who were completing research projects within the department were encouraged to participate if they had experience playing basketball.

Participants were required to be within the ages of 18-40 and be physically active. This was defined as participating in physical activity, either sport or exercise, at least twice a week. Prospective participants who had suffered an injury and/or undergone surgery to their lower limb(s) in the past year were excluded from participating in this study. Due to the limited funds available to purchase ankle braces, participants were required to have a shoe size (UK) between six and eleven. This ensured that the range of braces acquired would properly fit each participant's foot and ankle as per manufacturer guidelines.

Experimental protocol

Participants attended the gait XXX laboratory for a single testing session. Participants read a participant information sheet and completed a written consent form prior to partaking in the study. They were also informed about the anonymous and confidential storage of the data collected over the course of the research project. Lower-limb dominance was determined by asking which foot participants would use to kick a ball. Anthropometric measurements of mass, height, leg length, inter-ASIS (anterior superior iliac spine) width, knee-width, and ankle-width were measured and recorded. Ankle circumference was measured to assign the appropriate size of ankle brace. A proper fitting VivoBarefoot Evo Pure shoe was worn by all participants due to its thin sole and short quarter piece. The same model of shoe was used to minimize inconsistencies in testing. Twenty-four retro-reflective markers were fixed to the participant, according to a 24-marker foot-inversion model, using double-sided adhesive tape, that was devised at our motion analysis facilities. The markers were placed bilaterally on the anterior and posterior superior iliac spines, lateral aspect of the thigh, medial and lateral femoral epicondyles, lateral aspect of the shank, medial and lateral malleoli, first and fifth metatarsals, and on the heel and forefoot. The peroneus longus muscle belly was identified and marked by asking the participant to plantarflex and evert their foot. The skin on the identified area was shaved and treated using NuPrep gel to improve electrical conduction. EMG sensors were fixed on each peroneus longus muscle belly using the Delsys Trigno™ Sensor Skin Interface (SC-F03) and further secured using adhesive medical tape.

3D motion analysis and ground reaction forces were captured using a fourteen-camera Vicon Nexus Motion Capture system (Vicon Motion Systems Ltd., Oxford, UK) operated at 200 Hz. EMG activity was captured through a Delsys Trigno™ Wireless System (Delsys Inc., Massachusetts, USA). Data were collected simultaneously through the Vicon software using a desktop computer.

Participants completed both trials in a randomized order. These comprised an unbraced condition which served as a control, as well as a braced condition using an Ankle Stabilizing Orthosis (ASO) Ankle Brace (Medical Specialties, Inc., Charlotte, North Carolina, USA) (Figure 1). From its deepest to superficial layers, this brace consists of a lace-up boot, two nylon straps that cross on the dorsal aspect of the foot and fasten to the medial and lateral aspects of the shank, and an elastic cuff which is fastened around the circumference of the lower leg. The brace was worn on the dominant side only.

Rebounding apparatus

The rebounding apparatus was designed and custom-built within the XXX. The basketball was suspended from the devices lowest point using Velcro. The height at which the ball rested was adjustable to accommodate participants of different heights and jumping capabilities (Figure 2)

Rebounding task

Participants performed their regular exercise or sporting warm-up routine and were familiarized with the rebounding task prior to beginning data collection. The ball was set to a height that required the participant to jump to acquire it, but which would be attainable over a minimum of ten trials. During the rebounding task, participants began with each of their feet on its respective force plate, at a width apart that they would use naturally to jump. When signalled, participants would jump vertically, securing the basketball, and land down onto the force plates (Figure 2). Both feet were required to land completely within their respective force plates boundaries in order for the trial to be deemed successful. The rebounding task was performed in both braced and unbraced conditions and was repeated until five successful trials were obtained for each condition.

Data analysis

Using Vicon Nexus software, a 3D representation of each trial was formulated by manually marking all the reflective markers and running a custom foot inversion Pipeline. Gaps in the data were filled using the appropriate gap filling techniques.

The parameters observed include the maximum ankle inversion angle, maximum foot inversion angle, maximum ankle inversion moment, mean peak EMG activity and peak value EMG activity of peroneus longus.

Data from the whole trial were used when considering the maximum ankle and foot inversion angles. However, only data from the landing portion of the trial was considered when observing maximum ankle inversion moments and EMG activity of the peroneus longus. There were two reasons for this. The first reason was that there were no ground reaction forces present while the participant was in the air, therefore joint moments could not be calculated. Secondly, in each trial the peroneus longus had two spikes in EMG activity: while jumping, and while landing. The spike in activity due to the jump, if included in analysis, may have altered the interpretation of how the braces affected peroneus longus activity, and thus how the ankle and foot are stabilized during the landing portion.

Statistical Analysis

Data were analysed using IBM SPSS Version 22. The General Linear Model was used to calculate mean estimates of the four conditions, followed by pairwise comparisons to define any significant differences between these conditions. A p-value of 0.05 was used to establish statistical significance.

Results

A total of 16 participants completed the study. Fifteen were included for calculations involving maximum ankle and foot inversion angles and ankle inversion moments, while 14 were used for and EMG activity of the peroneus longus. Regarding inversion angles and moments, one participant's data was excluded due to too many gaps in Vicon data. Excessive gap filling techniques may have yielded unreliable data. Regarding peroneus longus EMG activity, two participants' data were excluded due to technical difficulties with the electrodes.

Table 1: Mean values and standard error of dominant side. UB Dominant = Mean for dominant limb in unbraced trials, ASO Dominant = Mean for dominant limb in ASO brace trials

	UB Dominant	SE	ASO Dominant	SE
Maximum ankle inversion angles (°)	5.649	0.468	4.094	0.343
Maximum foot inversion angles (°)	7.585	0.405	6.486	0.479
Maximum ankle inversion moments (Nm/kg)	0.278	0.023	0.335	0.031
Mean peak EMG activity of peroneus longus (mV)	0.035	0.002	0.045	0.006

Peak value EMG activity of peroneus longus (mV)	0.098	0.005	0.120	0.014

Table 2: Mean values and standard error of non-dominant ankle. UB Non-Dominant = Mean for non-dominant limb in unbraced trials, ASO Non-Dominant = Mean for non-dominant limb in ASO brace trials

	UB Non-dominant	SE	ASO Non-dominant	SE
Maximum ankle inversion angles (°)	6.572	0.595	6.413	0.569
Maximum foot inversion angles (°)	7.226	0.410	6.856	0.443
Maximum ankle inversion moments (Nm/kg)	0.348	0.030	0.337	0.030
Mean peak EMG activity of peroneus longus (mV)	0.055	0.003	0.054	0.003
Peak value EMG activity of peroneus longus (mV)	0.079	0.003	0.079	0.003

Table 3: Pairwise comparisons between braced and unbraced conditions. (UB - ASO) represents the difference between the mean value of the UB condition minus the mean value for the ASO condition.

	UB - ASO Dominant	p-value	UB - ASO Non-dominant	p-value
Maximum ankle inversion angles (°)	1.555	< 0.001*	0.159	0.159
Maximum foot inversion angles (°)	1.099	0.043*	0.410	0.355
Maximum ankle inversion moments (Nm/kg)	-0.056	<0.001*	0.011	0.449
Mean peak EMG activity of peroneus longus (mV)	-0.009	0.149	0.002	0.694
Peak value EMG activity of peroneus longus (mV)	-0.022	0.112	0.000	0.986

Discussion

Maximum ankle inversion angles

In the dominant ankle, the ASO Ankle brace significantly reduced maximum ankle inversion by 1.555° ($p < 0.001$) compared to the unbraced condition. No significant differences were noted in the non-dominant ankle.

The results in the braced condition supported the general consensus seen in the available literature that the ASO ankle brace decreases maximum ankle inversion compared to unbraced conditions

[16,17,18]. The similar angles between the unbraced, non-dominant ankles suggests that there were no compensations for the reduced range of motion in the dominant side.

Maximum foot inversion angles

Wearing the ASO ankle brace significantly reduced maximum foot inversion on the dominant side by 1.099^{o} ($p = 0.043$), but no statistically significant differences were found on the non-dominant side. Since the loading required to cause an injury changes with different positions of the foot, maintaining awareness and control of the foot in mid-air may be associated with preventing foot and ankle injuries [19]. One degree is clinically significant when considering that the maximum barefoot inversion whilst standing is less than 17 degrees. The current results are consistent with the studies that have demonstrated decreases in foot inversion while wearing an ankle brace [17,20].

Maximum ankle inversion moments

Increased ankle inversion moments were observed in the braced ankle when compared to the unbraced dominant ankle (0.056 Nm/kg, $p < 0.001$). No significant differences were seen in the non-dominant ankle.

The increased ankle moments may be related to the decreases in range of motion in the ankle joint. There is some evidence suggesting that a braced ankle performs less work during a landing task, relying on increased energy absorption in the hip and knees [21]. Therefore, the increased joint moments noted may be attributed to the distribution of forces to the more proximal aspects of the lower limb.

Mean peak EMG activity of peroneus longus

No significant differences were observed in either the dominant or non-dominant limbs regarding mean peak EMG activity of the peroneus longus. The similarities in readings between both trials may be explained by the repetitive task that was performed. The muscular activity required to land from a consistent height may not differ during braced and unbraced trials. Similar consistencies in mean peroneus longus activity have been found while performing change of direction manoeuvres in braced and unbraced conditions [22] and varying footwear configurations [23].

Peak value EMG activity of peroneus longus

No significant differences were noticed in the peak value EMG activity of the peroneus longus in either the dominant or non-dominant limbs. The lack of lateral movement is a potential explanation for the consistencies in peroneus longus activity. Since there were reductions in inversion angles and increases in ankle moments, it is assumed that forces were being distributed elsewhere than the ankle joint. Further studies should examine EMG activity of other muscles associated with landing from a height, as well as those used to stabilize the ankle joint.

Conclusion

There is a general consensus that wearing an ankle brace provides some protection against ankle injuries due to the increased mechanical support they give, which is likely associated with reducing ankle and foot inversion. However, the increased ankle inversion moments that occurred in the braced condition suggest that further studies need to be conducted to understand how forces are distributed when range of motion is restricted.

Brief Summary

What is known

- When compared to unbraced trials, ankle braces limit ankle and foot inversion.

What this study adds

- The results in the present study suggest that wearing an ankle brace unilaterally restricts inversion angles in the braced ankle, but does not affect the unbraced foot in terms of ankle and foot inversion angles, ankle inversion moments, or regarding mean peak EMG and peak value EMG activity of the peroneus longus.

- The increased moments in the braced limb, while maintaining consistent EMG activity of the peroneus longus during landing (mean and peak values), suggest that forces are being distributed elsewhere. Further studies should be conducted to evaluate the effects of ankle braces on other muscles associated with landing from a height.

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